BMK Boiler Pre-Installation Application Design Guide

AERCO®

PRE-INSTALL DESIGN GUIDE
750, 1000, 1500, 2000, 2500, 3000, 5000, and 6000 MBH Boilers

BOILER APPLICATIONS

Benchmark & Benchmark® Platinum Boilers
Natural Gas, Propane Gas, or Dual Fuel Fired Modulating, Condensing Boilers

Boiler pre-installation guidelines for Single/Multiple Installations, Piping, Controls, and Typical Applications

Applies to all versions of the following Benchmark and Benchmark® Platinum models:
- BMK 750
- BMK 1000
- BMK 1500
- BMK 2000
- BMK 2500
- BMK 3000
- BMK 5000
- BMK 6000

Latest Update: 11/01/2016

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GENERAL

AERCO BENCHMARK (BMK) boilers can be used in any hydronic closed-loop heating system application, within the limitations of temperature and pressure ratings. Because of their extreme flexibility and precise control, they can be used to supplement any hot water system. This guide is intended to help designers apply AERCO boilers to the most common types of systems. If a special application is needed, please call your local AERCO Representative or the AERCO factory for specific application information. CAD drawing packages are available for layout specification.

SINGLE AND MULTIPLE APPLICATIONS

AERCO BMK boilers can be applied either as stand-alone single units or in multiple batteries of boilers with unlimited input. BMK multiple boiler systems minimize floor space requirements and more importantly, modulate under partial loads to match the changing requirements of the energy input.

Actual boiler sizing and selection are the responsibility of the designer. ASHRAE standards recommend sizing equipment with a minimum of over sizing for maximum system efficiency. A multiple BMK boiler installation matches any load fluctuation from 0 to 100% without overshoot. AERCO subscribes to and recommends the methods used by ASHRAE and IBR to develop required loads and sizes.

PIPING

1.1 Pressure, Temperature, and Flow Restrictions

The maximum working pressure for the BMK 5000 & 6000 is either 80 psig (551 kPa) or 150 psig (1034 kPa). BMK 750 through 3000 Series units are ASME certified for working pressures of up to 160 psig (1103 kPa). BMK boilers cannot be used in applications where their allowable pressure ratings can be exceeded, or irreparable damage may result.

Individual ASME pressure relief valves are supplied on each boiler in setpoints of 30, 50, 60, 75, 100, 125, 150, or 160 psig (207, 414, 517, 689, 862, 1034, or 1103 kPa), as specified.

NOTE:
The piping connections illustrated throughout this bulletin are based on the BMK 1500-6000. See dimensional drawings for connection locations for Benchmark models.
AERCO BMK boilers require the following minimum flow per boiler for proper and stable boiler temperature control operation:

<table>
<thead>
<tr>
<th>BMK Model</th>
<th>Minimum Flow Per Boiler</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMK 750</td>
<td>12 gallons (45 L) per minute</td>
</tr>
<tr>
<td>BMK 1000</td>
<td>25 gallons (95 L) per minute</td>
</tr>
<tr>
<td>BMK 1500</td>
<td>25 gallons (95 L) per minute</td>
</tr>
<tr>
<td>BMK 2000</td>
<td>350 gallons (1325 L) per minute</td>
</tr>
<tr>
<td>BMK 2500</td>
<td>350 gallons (1325 L) per minute</td>
</tr>
<tr>
<td>BMK 3000</td>
<td>75 gallons (284 L) per minute</td>
</tr>
<tr>
<td>BMK 5000</td>
<td>700 gallons (2271 L) per minute</td>
</tr>
<tr>
<td>BMK 6000</td>
<td>700 gallons (2271 L) per minute</td>
</tr>
</tbody>
</table>

To prevent erosion of construction materials, maximum flows are limited to the following:

<table>
<thead>
<tr>
<th>BMK Model</th>
<th>Maximum Flow Per Boiler</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMK 750</td>
<td>175 gallons (662 L) per minute</td>
</tr>
<tr>
<td>BMK 1000</td>
<td>250 gallons (946 L) per minute</td>
</tr>
<tr>
<td>BMK 1500</td>
<td>250 gallons (946 L) per minute</td>
</tr>
<tr>
<td>BMK 2000</td>
<td>350 gallons (1325 L) per minute</td>
</tr>
<tr>
<td>BMK 2500</td>
<td>350 gallons (1325 L) per minute</td>
</tr>
<tr>
<td>BMK 3000</td>
<td>700 gallons (2271 L) per minute</td>
</tr>
<tr>
<td>BMK 5000</td>
<td>700 gallons (2271 L) per minute</td>
</tr>
<tr>
<td>BMK 6000</td>
<td>700 gallons (2271 L) per minute</td>
</tr>
</tbody>
</table>
Whenever BMK boilers are employed in systems where ancillary flow devices (such as three-way valves) are not used, minimum flows must be maintained for proper boiler operation.

BMK units are applicable to systems with temperatures from 50 °F to 190 °F (10 °C to 88 °C). Due to their condensing design, normal low temperature restrictions do not apply. While most common heating applications are designed with a 20 °F (11 °C) temperature drop, BMK boilers are capable of 100 °F (55 °C) temperature drop through the heat exchanger without thermal stress.

### 1.3 Multiple Boiler Piping Design

For multiple boiler installations, the piping must be designed to ensure balanced flow through all the boilers. This can be accomplished by using reverse-return piping or a balancing valve at the outlet of each boiler. Failure to balance flow evenly through the boilers will prevent full delivery of boiler capability at design conditions and may cause over-cycling and unnecessary stress on the boilers.

### 1.4 Service Provisions

For maintenance purposes, each BMK boiler should be individually valved on supply and return from the system. The BMK boiler is approved for “0” side clearance in two-unit pairs in applications where space is at a premium (with the exception of Benchmark® Platinum 5000 and 6000 models). Piping should be located to allow free access between boilers. Each unit has an individual factory-installed drain in the boiler shell.

### 1.5 Hydronic System Accessories

AERCO BMK boilers must be used in conjunction with appropriate hydronic accessories, such as pumps, expansion tanks and air elimination equipment.

Normal commercial and industrial systems employ constant-speed pumping equipment. Variable-flow pumping equipment may also be employed, as long as the system is operated within the recommended minimum and maximum boiler flow limits. Controls should activate heating pumps whenever BMK boilers are in operation.

Air elimination in conjunction with pre-charged diaphragm expansion tanks is preferable to air control. Compression tanks may be used, but create a maintenance task for system operators. Make-up systems must be employed as required by codes.

Fill valves must be used with backflow preventers, as required. Traditional flow control or mixing devices (primary-secondary pumping, 3-way valves) are not required with AERCO BMK boilers. However, when such devices are employed, they should always provide the minimum flows required for a single or multiple boiler installation. When used with a refrigeration (chiller) system, the boiler must be installed so as to prevent the chilled medium from entering the boiler. Consult your local AERCO representative for application advice.
1.6 Condensate Piping

Each AERCO BMK boiler has a separate indirect condensate drain and is supplied with a trap that must be permanently piped as part of the installation. BMK boilers must be installed on a 4-inch pad, minimum, to enable the condensate to drain from the exhaust outlet connection.

Each unit will produce the following approximate condensate quantities in the full condensing mode, depending on the local temperature and humidity:

<table>
<thead>
<tr>
<th>BMK MODEL</th>
<th>MAXIMUM CONDENSATE FLOW PER BOILER</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMK 750</td>
<td>6 gallons (23 L) per hour</td>
</tr>
<tr>
<td>BMK 1000</td>
<td>8 gallons (30 L) per hour</td>
</tr>
<tr>
<td>BMK 1500</td>
<td>9 gallons (34 L) per hour</td>
</tr>
<tr>
<td>BMK 2000</td>
<td>10 gallons (38 L) per hour</td>
</tr>
<tr>
<td>BMK 2500</td>
<td>17 gallons (64 L) per hour</td>
</tr>
<tr>
<td>BMK 3000</td>
<td>20 gallons (76 L) per hour</td>
</tr>
<tr>
<td>BMK 5000</td>
<td>34 gallons (129 L) per hour</td>
</tr>
<tr>
<td>BMK 6000</td>
<td>40 gallons (151 L) per hour</td>
</tr>
</tbody>
</table>

Condensate drain systems must be sized for full condensing mode.

In multiple boiler applications, it is common to manifold these drains together in a plastic pipe manifold to a floor drain. Condensate manifolds must be large enough to handle the anticipated flow and must be properly secured and protected. Manifolds are generally located behind the boilers so that short runs of plastic tubing into the manifold can be used for the condensate drain. A base drain must be installed at the bottom of vertical common flue piping (see Figure 13 of the Benchmark Venting and Combustion Air Guide, TAG-0022, GF-2050).

Condensate can be drained by gravity to a floor drain, or condensate may be drained into a small condensate pump (such as used with air conditioning equipment) and pumped to a convenient drain.

The pH level of the condensate produced by BMK boilers ranges between 3.0 and 3.2. The installation should be designed in accordance with local codes that specify acceptable pH limits. If the condensate pH level needs to be raised to comply with local codes, the AERCO Condensate Neutralizer Kit may be used. See Technical Instructions TID-0029 for details. When using the AERCO Condensate Neutralizer Tank, for proper condensate drainage, the neutralizer tank must be installed in a pit OR the boiler and the AERCO Condensate Trap must be elevated higher than 4” (10 cm) above the floor. See Condensate Tank instructions TID-0074 for details.

1.7 Safety Control

BMK boilers are equipped with a manual reset high-limit aquastat. Each BMK boiler has safety controls that comply with ASME Section IV for low pressure boilers. These controls are factory wired and installed to simplify field installation. An internal, electric, probe-type, low water cutoff and a manual-reset high-limit temperature device comply with ASME standards. Other locally-required external safety devices (flow switches, pressure controls, etc.) should be provided and installed locally. Designers should check with local authorities having jurisdiction to assure compliance with all applicable codes.
1.8 Internal Boiler Operating Control Options

BMK boilers are shipped complete with both combustion safeguard controls and operating controls installed in each unit. Whether in a single or multiple boiler application, Benchmark boilers can operate in a variety of control modes including Internal Setpoint, Outdoor Reset or Remote Signal. When used in a multiple boiler application, boiler control modes must be specified and ordered with those found in the following table:

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>OUTPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>External Setpoint</td>
<td>Outdoor Reset</td>
</tr>
<tr>
<td>Modbus AERCO ACS</td>
<td>Fire Rate Response to ACS signal, 9 or more boilers</td>
</tr>
<tr>
<td>On Board BST</td>
<td>Fire Rate Response to integrated BST signal, 2 to 8 boilers</td>
</tr>
</tbody>
</table>

Factory software and testing facilitate a simple installation, with minimum field wiring required.

When 9 or more BMK boilers and an AERCO Control System (ACS) are applied in a multiple-boiler application, all the modules should be specified and ordered as ACS compatible. In this configuration, simple field control wiring consisting of two twisted wires connects the ACS Panel to the individual boilers.

1.9 Field Sensor Location

When a single BMK boiler is used, all water sensors are internal to the boiler unit and factory positioned. When multiple boilers with on-board sequencing or ACS are used, and therefore have a common sensor such as the Header Sensor, the sensor must be located in the field piping. It should be placed in the common supply at least 2 to 10 feet (0.6 to 3.1 m) downstream of the point where the last boiler connects into the supply header.

All outdoor air sensors should be positioned on the North wall of the building served, and not in direct sunlight. The outdoor air sensor should not be placed inside the boiler air inlet duct, or near the boiler exhaust outlet connection. A sunshield is provided as part of the outdoor air sensor kit.

1.10 Multiple Boiler Control

There are two alternatives for controlling multiple boilers:

- **On Board Boiler Sequencing Technology (BST):** Can control from 2 to 8 boilers. BST is an integrated boiler control system incorporated into the C-More controller. BST has its own sophisticated PID control system designed to simultaneously control the light off and modulation of up to 8 boilers while achieving maximum operational efficiency.

- **AERCO Control System (ACS):** Can control from 9 to 32 boilers as well as auxiliary equipment. ACS maximizes the plant efficiency by running the boilers at their lowest possible input. Refer to ACS specification sheet for full details of the ACS flexibility.

In both cases, Benchmark units should be specified and ordered with the desired control configuration (see table above), either BST or ACS.
BMK boilers can be used in any closed-loop heating system within their design limitations. The following typical piping and wiring schematic diagrams represent the most common types of installation detail. These diagrams are not intended for any particular system, but are rather composites of how AERCO boilers interface with heating applications in the real world.

The designer should incorporate BMK boiler(s) in each system so as to achieve maximum operating efficiency. With ultimate control over the energy transfer process under a broad range of temperatures, the designer should first consider how the system best needs the supplied energy. The boilers should then be applied in the manner that best enables them to use their finite control and capability to supplement the system, using minimum applied energy.

The following examples illustrate typical piping and wiring diagrams with brief explanations of design considerations and sequences of operation. The examples include:

- Diagram 2 – Single Boiler Piping Schematic
- Diagram 3 – System Pump Start schematic – Using Pump Relay or Separate Contact Relay
- Diagram 4 – Multiple Boiler Piping with Boiler Sequencing Technology (BST)
- Diagram 5 – Multiple Boilers, Duel Returns, with multiple connections
- Diagram 6 – Two Boilers, Duel Returns, with Space Heating and Snowmelt/Pool Heater
- Diagram 7 – BST Field Wiring Diagram (24 VAC)
- Diagram 8 – BST Field Wiring Diagram (24 VAC) with Modbus Channel Device
- Diagram 9 – Multiple Boiler Piping with motorized control valves
- Diagram 10 – Multiple Benchmark 5000/6000 Units with Buffer Tank & SmartPlate
- Diagram 11 – Three Boilers & SmartPlate Combination Heating/Domestic Hot Water
- Diagram 12 – Three Boiler Combination Heating/Domestic Hot Water Piping with ACS
- Diagram 13 – Multiple Boiler Installation Piping – Primary/Secondary Pumping
- Diagram 14 – Multiple BMK 2000 Boilers and Motorized Control Valves (if ACS is used)

Designers are encouraged to work with their AERCO representative to fully explore and apply the ultimate exchange of energy with control in hydronic heating.

### 1.11 Single Boiler — Heating Only

**Sequence of Operation:**

Boiler plant should be activated by a system start device, such as an outdoor air thermostat or building management system.

A manual switch can be used, but it would place the burden of starting and stopping on the boiler attendant. Automatic controls are more desirable.

Using the standard Benchmark boiler pump relay, the system’s circulating pump should be started with the BMK unit and should be constant run, as illustrated in Diagram 3. A flow switch or other method should be used to prevent the BMK unit from firing under no flow. If used, the flow switch must be wired to the delayed interlock of the BMK C-More Controls (see C-More Manual GF-112 for details. A unit energized to fire with insufficient or no flow will trip out on high temperature limit.

Once activated, the internal boiler temperature controls will modulate the input of the boiler to match the control algorithm set.

With indoor/outdoor reset mode, the temperature of the boiler water to the system will increase as the outdoor temperature decreases. The rate of change can be varied by the adjustable reset
ratio on the boiler control panel.

Diagram 2: Single Boiler Piping Schematic (BMK 3000/2500 shown)

NOTE:
This piping schematic is applicable to all BMK models. Refer to Appendix A for the schematics specifically for BMK 750-1000 and BMK 5000-6000 units.

Diagram 3: Schematic – System Pump Start

Using the Benchmark Boiler Pump Relay

Using a Separate Contact Relay in Conjunction with the Benchmark Boiler Pump Relay
1.12 Multiple Boiler — Heating Only

Benchmark multiple boiler plants provide the ultimate energy conversion for building space heating, longevity and ease of installation. Boiler plants incorporating from 2 to 8 boilers can be controlled via AERCO’S on-board Boiler Sequencing Technology (BST). Boiler plants with 9 to 32 boilers can be controlled from a separate single AERCO Control System (ACS). Boilers can be arranged in back-to-back or inline piping applications, as space permits. Boiler plant layouts should incorporate sufficient space for normal maintenance and operation.

Sequence of Operation:

In a multiple-boiler plant consisting of 2 to 8 boilers, utilizing the on-board BST is recommended. The Multiple boiler plant consisting of 9-32 boilers, an ACS is recommended. Both BST/ACS have an Internal Plant Start adjustment that can be set for a 30 °F to 100 °F (-1.1 °C to 37.8 °C) outdoor air temperature range. When the boiler plant is activated, the system pump should be started simultaneously. This can be controlled from the building automation system (BAS), from the BST/ACS via the boiler pump relay (wired in parallel for all the boilers in the plant) or system start relay (see Diagram 3). A flow switch or other method should be interlocked with the BAS to prevent the boilers from firing in the no-flow state. When activated, the BST/ACS will stage on the first boiler and increase the boiler input to increase header temperature.

- ACS
  The first boiler will increase input, as required, until a percentage of input that is twice the boiler start level percentage (user programmed in the ACS) is reached. At that point, the ACS will start a second boiler and run both at their start level percentage. The two boilers will continue to increase their energy input, as required by the ACS. When the two firing boilers reach a combined percentage input that is three times the boiler start percentage, the ACS will start a third boiler and run all three at their start level percentage to minimize temperature fluctuation. As the load increases as described above, the ACS will stage the fourth boiler on at the start level percentage transfer setpoint and bring input on all boilers up as needed.

- Onboard BST
  The first boiler will increase input, as required, until 50% fire rate valve position (user programmed in the BST menu) is reached. Boiler inputs will modulate At that point, the BST will start a second boiler and run both at 30% percent fire rate valve position. The two boilers will continue to increase their energy input, as required by the BST. When the two firing boilers reach a combined percentage input of 50%, the BST will start a third boiler and run all three at 30% fire rate valve position to minimize temperature fluctuation. As the load increases as described above, the BST will stage the fourth boiler on at 50% transfer setpoint and bring input on all boilers up as needed.

Boiler inputs will modulate down in response to the BST/ACS in a reverse manner. Each boiler will come off line at the boiler stop level percentage transfer setpoint to maximize condensing. Whether the BMS/ACS is set in a constant temperature or modulating temperature mode, it will use its modulating ability to prevent header temperature fluctuation and maximize efficiency. Also, the BST/ACS can enable auxiliary equipment, such as system pumps and fans. Refer to the onboard BST or ACS Product Specification for details.
Diagram 4: Multiple Boiler Piping Schematic with Boiler Sequencing Technology (BMK 1500/2000 units shown)

1.13 Multiple Boiler Heating Plant — with Individual Isolation Valves

Systems designed with variable speed pumps (VFD) enable plants to use less pump energy during low heating load conditions. For these types of systems, the following must be observed.

1. When idle boilers are isolated from the system during low load conditions, the VFD system must operate within the recommended minimum flow requirement of the operating boilers. As an example, consider a system with four BMK 6000 boilers: when two boilers are idle and isolated from the system during low-load conditions, the flow rate to the two operating boilers must be at least $75 \text{ gpm} \times 2 = 150 \text{ gpm}$ ($284 \text{ L/min} \times 2 = 568 \text{ L/min}$).

2. When an operating boiler is satisfied and becomes idle, operators should allow a minimum of 2 minutes before isolating it from the system flow. This ensures that heat is dissipated from the heat exchanger and prevents nuisance over-temperature conditions.

Sequence of Operation:

- **For ACS installations** — Includes the ACS Control Panel and a Boiler Valve Controller (BVC) Panel. The BVC manages the isolation of idle boilers from the system flow. The BVC is wired to the isolation valves and to the boiler auxiliary relays on each unit’s I/O board. During demand, either the BVC or the auxiliary relay signals the BVC Panel to open the corresponding isolation valve. Isolation valves MUST have proof-of-open switch and the switch must be interlocked to the boiler (Delayed Interlock) to prevent the unit from firing until the valve is fully open.
For BST installations – BST is integrated in the C-More Controller of each unit, with one unit acting as the “Master” and all others as “slave” units. The Master controls its own isolation valve and sends signals to the slave units to open or close their isolation valves.

For both ACS and BST, after the boiler load is satisfied, the isolation valve remains open for a programmed interval (default = 2 minutes) before closing. When the system load is satisfied, the ACS panel or BST will open the isolation valves for all of the boilers.

Diagram 7 illustrates a typical wiring of isolation valves to the boiler. Diagram 9 illustrates a three-boiler plant with individual motorized isolation valves.

### 1.14 Primary-Secondary Pumping

The typical piping layouts discussed in the previous paragraphs cover most BMK applications. Ordinarily, primary-secondary pumping is not required for proper operation of BMK boiler systems. However, if the system is designed with primary-secondary pumping, Diagram 13 provides a guideline for near-boiler piping to ensure correct boiler flow rate. A water source heat pump is an example of an application in which primary-secondary pumping may be used.

If ACS or BST is used in a primary-secondary application (see Diagram 13), then:

1. A header sensor must be installed in the header, between 2 and 10 feet (0.6 and 3.1 m) from the pipe junction.
2. If desired, individual boiler pumps may be enabled through the Benchmark boiler pump relay (see Diagram 3).
3. For ACS only, sequenced isolation valve control and the ability to open all isolation valves after system load is satisfied requires the AERCO Boiler Valve Controller (BVC).

**Sequence of Operation:**

In water source heat pump systems, the boilers supplement the loop to maintain a constant water temperature. The 60 °F to 90 °F (15.6 °C to 32.2 °C) temperature range is too low for conventional fossil fuel boilers because condensation will form in the firesides causing corrosion. AERCO BMK units are built with a 439 stainless steel heat exchanger to withstand corrosion. BMK boilers excel in this type of application because the low return water temperature maximizes their condensing capability.

Normally, the boiler plant is activated from the Main Heat Pump Control/Sequence Panel when the system requires auxiliary heat. Once activated, the boilers will modulate independently to maintain the loop temperature.

- If an ACS panel is used, the Main Controls will activate the ACS, which in turn modulates the boilers to maintain the loop temperature. Extremely close tolerances to the temperature setpoint will be maintained.
- If BST is used, the Main Controls will activate the integrated BST control which will in turn modulate the boiler plant.
1.15 Three Boiler Combination Heating and Domestic Water System

A combination heating and domestic hot water plant can be specified to share the loads among common boilers. Some benefits of combining heating and domestic load into a single plant include first-cost control, simplified venting, and simplified operation.

The heating load should be developed from ASHRAE or industry standard methods, and the domestic water load should be sized using conventional sizing criteria.

The domestic water can be generated in an external hot water storage generator (a storage tank with a water-to-water exchanger), or through an instantaneous or semi-instantaneous system. When using a hot water storage generator design for a replacement system, the size of the storage tank is fixed and sufficient recovery must be provided. For a new application, tank storage should be sized with sufficient capacity to prevent the boiler(s) from short-cycling under low loads.

When using instantaneous or semi-instantaneous systems, thermal mass must be added to the boiler water loop as a buffer to dampen out fast transitions and minimize boiler cycling. These conditions can occur either during zero load or during low load situations in which the only load is generated by recirculation piping losses. The ACS Control and Relay Panels are recommended for this application.

Diagram 11 illustrates proper piping for a buffer tank and AERCO’s packaged plate heat exchanger (SmartPlate), piped as a zone with the boilers and the combination heating/domestic hot water system.

Sequence of Operation: The SmartPlate setpoint is set for the desired domestic water temperature. As domestic load occurs, the SmartPlate will open its control valve to permit boiler water to flow through the plate heat exchanger. The ACS Panel will fire the boilers as necessary to deliver the required energy (see the ACS/DHW Application Guide TAG-0050 for details). The pump between the SmartPlate and the buffer tank will constantly circulate boiler water, by-passing the plate heat exchanger when the domestic load is satisfied.

1.16 Dual Returns

Benchmark® Platinum 750-6000 boilers come standard with dual return connections. Utilizing this feature can boost seasonal efficiency by up to 7%. Installations with space heating and the following applications that can take advantage of this feature include:

- Domestic hot water applications
- Higher ∆T zones with lower return temperatures
- Air preheat
- Heat pump injection
- And more

Rather than blend the separate zones, the lower return temperature zones/systems could be piped separately to the primary water connection, raising the overall thermal efficiency and allowing the boiler to be in condensing mode for longer periods throughout the year. Please see the chart and application examples below for additional information.
### BMK Boiler Pre-Installation Application Design Guide

**DUAL RETURN MAXIMUM EFFICIENCY GAIN**

<table>
<thead>
<tr>
<th>MODEL</th>
<th>MAXIMUM EFFICIENCY GAIN</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMK 750 / 1000</td>
<td>7.0%+</td>
</tr>
<tr>
<td>BMK 1500 / 2000</td>
<td>7.0%+</td>
</tr>
<tr>
<td>BMK 2500 / 3000</td>
<td>7.0%+</td>
</tr>
</tbody>
</table>

*Values based on a minimum 80°F (26.7°C) return water temperature. Lower return temperatures are possible. There is no minimum return water temperature for Benchmark boilers. Maximum ΔT across the boiler is 100°F (37.8°C). Consult your local AERCO Sales Representative or the AERCO factory for additional information.

### OPTIMAL UTILIZATION OF DUAL RETURN CONNECTIONS APPLICATION EXAMPLE:

#### BMK 750/1000

<table>
<thead>
<tr>
<th>Flow Split %</th>
<th>TEMPERATURE RANGE</th>
<th>EFFICIENCY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>120°F-160°F (49°C-71°C)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>140°F-180°F (60°C-82°C)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>80°F-120°F-160°F (27°C-49°C-71°C)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>100°F-140°F-180°F (38°C-60°C-82°C)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>80°F-140°F-180°F (27°C-60°C-82°C)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Flow Split %</th>
<th>EFFICIENCY</th>
</tr>
</thead>
<tbody>
<tr>
<td>0/100</td>
<td>89.9%</td>
</tr>
<tr>
<td>80/20</td>
<td>88.5%</td>
</tr>
<tr>
<td>60/40</td>
<td>TBD</td>
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#### BMK 1500/2000

<table>
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<th>Flow Split %</th>
<th>TEMPERATURE RANGE</th>
<th>EFFICIENCY</th>
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<tbody>
<tr>
<td></td>
<td>120°F-160°F (49°C-71°C)</td>
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<tr>
<td></td>
<td>140°F-180°F (60°C-82°C)</td>
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<tr>
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<td>80°F-120°F-160°F (27°C-49°C-71°C)</td>
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<tr>
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<td>100°F-140°F-180°F (38°C-60°C-82°C)</td>
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<tr>
<td></td>
<td>80°F-140°F-180°F (27°C-60°C-82°C)</td>
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<table>
<thead>
<tr>
<th>Flow Split %</th>
<th>EFFICIENCY</th>
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</thead>
<tbody>
<tr>
<td>0/100</td>
<td>89.7%</td>
</tr>
<tr>
<td>80/20</td>
<td>87.8%</td>
</tr>
<tr>
<td>60/40</td>
<td>94.6%</td>
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#### BMK 2500/3000

<table>
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<th>Flow Split %</th>
<th>TEMPERATURE RANGE</th>
<th>EFFICIENCY</th>
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<tbody>
<tr>
<td></td>
<td>120°F-160°F (49°C-71°C)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>140°F-180°F (60°C-82°C)</td>
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<td>80°F-120°F-160°F (27°C-49°C-71°C)</td>
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<td></td>
<td>100°F-140°F-180°F (38°C-60°C-82°C)</td>
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</tr>
<tr>
<td></td>
<td>80°F-140°F-180°F (27°C-60°C-82°C)</td>
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<table>
<thead>
<tr>
<th>Flow Split %</th>
<th>EFFICIENCY</th>
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</thead>
<tbody>
<tr>
<td>0/100</td>
<td>89.1%</td>
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<td>80/20</td>
<td>87.8%</td>
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<tr>
<td>60/40</td>
<td>93.9%</td>
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*Efficiency Values are at full fire. Higher values can be obtained at lower fire rates.

### CHART GUIDE:

- **Flow Split % (Percentage)** = Secondary (Hi-Temp) Return Flow % / Primary (Lo Temp) Return Flow %
- **Temperature Range Example:** 120°-140°-180° = Lo Temp Return Temp. – Hi Temp Return Temp. – Supply Temp.

### NOTE:

The BMK 5000/6000 dual return efficiency gain, along with additional BMK750/1000 data, will be available in January 2017.
The chart above demonstrates Benchmark efficiency gains based on 20% primary (low temp.) return flow and 80% secondary (high temp.) return flow, with 180°F supply setpoint. Additional graphical representation of efficiency gains will be available in January 2017.

Multiple flow configurations are possible. There is no minimum flow requirement for the primary-low temperature return, as long as the minimum flow requirements of the boiler models are met through the secondary-high temperature return. If the flow split between the high and low temperature returns is constant, the total flow must be no less than the minimum flow requirements of the boiler models. Due to the varying flow conditions possible when utilizing dual returns, AERCO recommends installing check valves at both inlets of the boiler(s), as shown below.

Consult your local AERCO sales representative or the AERCO factory for additional information. See Diagrams 5 and 6, below, for examples.
Diagram 5: Benchmark® Platinum 2500-3000 Multi-Unit Space Heating, Snowmelt Heating, DHW SmartPlate, and Buffer Tank Application with Dual Returns
Diagram 6: Benchmark® Platinum Boilers with Space Heating and Snowmelt/Pool Heat Applications with Dual Returns

Notes:
1. See Benchmark Applications Guide GF-2070 for Dual Return Application Details.
2. The above diagram depicts the combination heating/snowmelt or pool heat piping only. For gas piping and the rest of the water-side piping details, see appropriate Benchmark boiler piping schematic.
3. For actual sizes and locations of piping and other connections to the boiler, see appropriate Benchmark boiler dimensional drawing.
4. This is a typical installation drawing. Local codes and authorities should be consulted.
5. The snowmelt/pool heat system pump may be enabled/disabled by snowmelt/pool heat system control.
6. Header temp. sensor must be installed between 2 to 10 feet away from last unit connection to common header.
7. Boiler pump must be sized to provide the appropriate flow at the design ∆T of boiler plant. Maximum ∆T across boiler is 100°F. Boiler pump must maintain Benchmark boiler(s) required minimum flow of 25 GPM (95 L/min.).
Diagram 8. BST Field Wiring Diagram (24VAC) with Modbus Channel Device
Reference SD-A-1089 rev C

NOTES:
1. FOR ACTUAL SIZES AND LOCATIONS OF PIPING AND OTHER CONNECTIONS TO THE HEATER, SEE DIMENSIONAL DRAWING.
2. SHELL DRAIN VALVE AND CONDENSATE HOSE SHOULD BE ARRANGED TO PERMIT THE FLUIDS TO DRAIN FREELY, BY GRAVITY, TO A FLOOR DRAIN. RELIEF VALVE DISCHARGE SHOULD BE PIPED TO THE NEAREST FLOOR DRAIN. WHEN NO FLOOR DRAIN IS AVAILABLE, THE RELIEF VALVE DISCHARGE SHOULD BE PIPED VERTICALLY TO A HEIGHT 18” ABOVE THE FLOOR.
3. ALL (*) ITEMS ARE INCLUDED SEPARATELY IN SHIPMENT.
4. LOCATE WATER INLET AND OUTLET FITTINGS (i.e.,UNIONS, ELBOWS, ETC.) A MINIMUM OF 6” FROM HEATER FITTINGS, TO PREVENT INTERFERENCE WITH REMOVAL OF BOILER PANELS AND COVERS. ALL PIPING AND ELECTRIC CONNECTIONS (SERVICE SWITCHES, CONDUIT BOXES) SHOULD LIKewise BE 6” AWAY FROM SIDE PANELS.
5. BOILER PUMP MUST BE SIZED TO PROVIDE THE APPROPRIATE FLOW AT THE DESIGN ΔT OF BOILER PLANT. MAXIMUM ΔT ACROSS BOILER IS 100°F. BOILER PUMP MUST MAINTAIN BENCHMARK BOILER(S) REQUIRED MINIMUM FLOW OF 25 GPM.
6. THIS IS A TYPICAL INSTALLATION DRAWING. LOCAL CODES AND AUTHORITIES SHOULD BE CONSULTED.
7. WHEN USING THE AERCO CONDENSATE NEUTRALIZER TANK, FOR PROPER CONDENSATE DRAINAGE, THE NEUTRALIZER TANK MUST BE INSTALLED IN A PIT OR THE BOILER AND THE AERCO CONDENSATE TRAP MUST BE ELEVATED 4” OR HIGHER ABOVE THE FLOOR. SEE CONDENSATE TANK INSTRUCTIONS T10-0074 FOR DETAILS.
8. REVIEW BENCHMARK GAS SUPPLY DESIGN GUIDE GF-2030 FOR GAS PIPING INSTALLATION INSTRUCTIONS.
9. HEADER SENSOR MUST BE INSTALLED BETWEEN 2 TO 10 FEET FROM JUNCTION AND FROM LAST UNIT.
10. CONSULT AERCO FOR ADDITIONAL INFORMATION OR DIFFERENT DESIGN CONDITIONS.
11. USE OF BALANCING VALVES IS RECOMMENDED IF THE PIPING ARRANGEMENT IS NOT REVERSE RETURN.

**Diagram 9: Multiple Boiler Piping Schematic with Motorized Valves**

(Benchmark® Platinum 1500/2000 units shown)
SEE THE BENCHMARK GAS SUPPLY DESIGN GUIDE GF-2030 FOR GAS PRESSURE REQUIREMENTS.

Diagram 10: Multiple Benchmark® Platinum 5000/6000 Units with Buffer Tank & SmartPlate

Notes:
1. For actual sizes and locations of piping and other connections to the heater, see dimensional drawing.
2. Shell drain valve and condensate hose should be arranged to permit the fluids to drain freely, by gravity, to a floor drain. Relief valve discharge should be piped to the nearest floor drain. When no floor drain is available, the relief valve discharge should be piped vertically to a height 18" above the floor.
3. All (*) items are included separately in shipment.
4. Locate water inlet and outlet fittings (i.e., unions, elbows, etc.) a minimum of 6" from heater fittings, to prevent interference with removal of boiler panels and covers. All piping and electric connections (service switches, conduit boxes) should likewise be 6" away from side panels.
5. Refer to SmartPlate applications guide, SP−1010, for buffer tank sizing.
6. Refer to SmartPlate installation drawings for recommended domestic piping installation:
   SD-A=772, SD-A=773, SD-A=774, SD-A=775, SD-A=776, SD-A=777
7. System pump or system design must maintain Benchmark 5000/6000 boiler(s) required minimum flow of 75 GPM.
8. This is a typical installation drawing. Local codes and authorities should be consulted.
9. When using the AERCO condensate neutralizer tank, for proper condensate drainage, the neutralizer tank must be installed in a pit or boiler and the AERCO condensate trap must be elevated 4" or higher above the floor. See condensate tank instructions TD−0074 for details.
10. Zero−side clearance not approved for Benchmark® Platinum 5000/6000 models.
Diagram 11. Three Boiler & SmartPlate Combination Heating/Domestic Hot Water
Diagram 12. Three Boiler Combination Heating & Domestic Hot Water Piping
Reference SD-A-960 rev D

NOTES:
1. FOR ACTUAL SIZES AND LOCATIONS OF PIPING AND OTHER CONNECTIONS TO THE HEATER, SEE DIMENSIONAL DRAWING.
2. SHELL DRAIN VALVE AND CONDENSATE HOSE SHOULD BE ARRANGED TO PERMIT THE FLUIDS TO DRAIN FREELY, BY GRAVITY, TO A FLOOR DRAIN. RELIEF VALVE DISCHARGE SHOULD BE PIPED TO THE NEAREST FLOOR DRAIN. WHEN NO FLOOR DRAIN IS AVAILABLE, THE RELIEF VALVE DISCHARGE SHOULD BE PIPED VERTICALLY TO A HEIGHT 18” ABOVE THE FLOOR.
3. ALL (*) ITEMS ARE INCLUDED SEPARATELY IN SHIPMENT.
4. THIS IS A TYPICAL INSTALLATION DRAWING. LOCAL CODES AND AUTHORITIES SHOULD BE CONSULTED.
5. LOCATE WATER INLET AND OUTLET FITTINGS (i.e. UNIONS, ELBOWS, ETC.) A MINIMUM OF 6” FROM WATER HEATER FITTINGS, TO PREVENT INTERFERENCE WITH REMOVAL OF HEATER PANELS.
6. WHEN AVAILABLE GAS PRESSURE IS GREATER THAN 14” W.C., A LOCK-UP STYLE REGULATOR MUST BE INSTALLED DOWNSTREAM OF THE MANUAL SHUTOFF VALVE TO BRING THE GAS PRESSURE DOWN TO 14” W.C. OR LESS.
7. WHEN USING THE AERCO CONDENSATE NEUTRALIZER TANK, FOR PROPER CONDENSATE DRAINAGE, THE NEUTRALIZER TANK MUST BE INSTALLED IN A PIT OR THE BOILER AND THE AERCO CONDENSATE TRAP MUST BE ELEVATED HIGHER THAN 4” ABOVE THE FLOOR. SEE CONDENSATE TANK INSTRUCTIONS TID-0074 FOR DETAILS.
8. REVIEW BENCHMARK GAS SUPPLY DESIGN GUIDE GF-2030 FOR GAS PIPING INSTALLATION INSTRUCTIONS.
9. IF AN ACS/BST IS USED, A HEADER SENSOR MUST BE INSTALLED BETWEEN 2 TO 10 FEET FROM PIPE JUNCTION.
10. CONSULT AERCO FOR ADDITIONAL INFORMATION OR DIFFERENT DESIGN CONDITIONS.

Diagram 13: Multiple Boiler Installation Piping – Primary/Secondary Pumping
Diagram 14: Multiple BMK 2000 Boilers and Motorized Control Valves (if ACS is used)
NOTES:
1. FOR ACTUAL SIZES AND LOCATIONS OF PIPING AND OTHER CONNECTIONS TO THE HEATER, SEE DIMENSIONAL DRAWING.
2. SHELL DRAIN VALVE AND CONDENSATE HOSE SHOULD BE ARRANGED TO PERMIT THE FLUIDS TO DRAIN FREELY: BY GRAVITY, TO A FLOOR DRAIN. RELIEF VALVE DISCHARGE SHOULD BE PIPED TO THE NEAREST FLOOR DRAIN. WHEN NO FLOOR DRAIN IS AVAILABLE, THE RELIEF VALVE DISCHARGE SHOULD BE PIPED VERTICALLY TO A HEIGHT 18" ABOVE THE FLOOR.
3. ALL (*) ITEMS ARE INCLUDED SEPARATELY IN SHIPMENT.
4. LOCATE WATER INLET AND OUTLET FITTINGS (i.e.,UNIONS, ELBOWS, ETC.) A MINIMUM OF 6" FROM HEATER FITTINGS, TO PREVENT INTERFERENCE WITH REMOVAL OF BOILER PANELS AND COVERS. ALL PIPING AND ELECTRIC CONNECTIONS (SERVICE SWITCHES, CONDUIT BOXES) SHOULD LIKEWISE BE 6" AWAY FROM SIDE PANELS.
5. BOILER PUMP MUST BE SIZED TO PROVIDE THE APPROPRIATE FLOW AT THE DESIGN ΔT OF BOILER PLANT. MAXIMUM ΔT ACROSS BOILER IS 100°F. BOILER PUMP MUST MAINTAIN BENCHMARK BOILER(S) REQUIRED MINIMUM FLOW OF 75 GPM.
6. THIS IS A TYPICAL INSTALLATION DRAWING. LOCAL CODES AND AUTHORITIES SHOULD BE CONSULTED.
7. WHEN USING THE AERCO CONDENSATE NEUTRALIZER TANK, FOR PROPER CONDENSATE DRAINAGE, THE NEUTRALIZER TANK MUST BE INSTALLED IN A PIT OR THE BOILER AND THE AERCO CONDENSATE TRAP MUST BE ELEVATED 4" OR HIGHER ABOVE THE FLOOR. SEE CONDENSATE TANK INSTRUCTIONS TID—0074 FOR DETAILS.
8. REVIEW BENCHMARK GAS SUPPLY DESIGN GUIDE GT—2030 FOR GAS PIPING INSTALLATION INSTRUCTIONS.
9. CONSULT AERCO FOR ADDITIONAL INFORMATION OR DIFFERENT DESIGN CONDITIONS.
NOTES:
1. FOR ACTUAL SIZES AND LOCATIONS OF PIPING AND OTHER CONNECTIONS TO THE HEATER, SEE DIMENSIONAL DRAWING.
2. SHELL DRAIN VALVE AND CONDENSATE HOSE SHOULD BE ARRANGED TO PERMIT THE FLUIDS TO DRAIN FREELY. BY GRAVITY, TO A FLOOR DRAIN. RELIEF VALVE DISCHARGE SHOULD BE PIPED TO THE NEAREST FLOOR DRAIN. WHEN NO FLOOR DRAIN IS AVAILABLE, THE RELIEF VALVE DISCHARGE SHOULD BE PIPED VERTICALLY TO A HEIGHT 18" ABOVE THE FLOOR.
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5. BOILER PUMP MUST BE SIZED TO PROVIDE THE APPROPRIATE FLOW AT THE DESIGN ΔT OF BOILER PLANT. MAXIMUM ΔT ACROSS BOILER IS 10°F. BOILER PUMP MUST MAINTAIN BENCHMARK BOILER(S) REQUIRED MINIMUM FLOW OF 75 GPM.
6. THIS IS A TYPICAL INSTALLATION DRAWING. LOCAL CODES AND AUTHORITIES SHOULD BE CONSULTED.
7. WHEN USING THE AERCO CONDENSATE NEUTRALIZER TANK, FOR PROPER CONDENSATE DRAINAGE, THE NEUTRALIZER TANK MUST BE INSTALLED IN A PIT OR THE BOILER AND THE AERCO CONDENSATE TRAP MUST BE ELEVATED 4" OR HIGHER ABOVE THE FLOOR; SEE CONDENSATE TANK INSTRUCTIONS T10-0074 FOR DETAILS.
8. REVIEW BENCHMARK GAS SUPPLY DESIGN GUIDE GF-2030 FOR GAS PIPING INSTALLATION INSTRUCTIONS.
9. HEADER SENSOR MUST BE INSTALLED BETWEEN 2 TO 10 FEET FROM JUNCTION AND FROM LAST UNIT.
10. CONSULT AERCO FOR ADDITIONAL INFORMATION OR DIFFERENT DESIGN CONDITIONS.
11. USE OF BALANCING VALVES IS RECOMMENDED IF THE PIPING ARRANGEMENT IS NOT REVERSE RETURN.
12. ZER0-SIDE CLEARANCE NOT APPROVED FOR BENCHMARK® PLATINUM 5000/6000 MODELS.
### CHANGE LOG:

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<td>04/16/2014</td>
<td><strong>Rev J:</strong> Added support in various locations for Boiler Sequencing Technology (BST), and distinguished it from ACS, added new Diagrams</td>
<td>Chris Blair</td>
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<tr>
<td>11/01/2016</td>
<td><strong>Rev K:</strong> Updated some values in section 3.1, added metric equivalent values (reference DIR 357, 359), added new diagrams. Updated to new design standard.</td>
<td>Chris Blair/ Curtis Harvey</td>
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